

ABSTRACT

A reformer for reacting fuel (12) and oxidant (16, 18, 20) into reformat (22). The reformer has an oxidizing zone (24), a reforming zone (26) and an injection and mixture forming zone between the oxidizing zone (24) and the reforming zone (26). A mixture of fuel (12) and oxidant (16, 18, 20) is delivered to the oxidizing zone (24) and is delivered at least in part to the reforming zone (26) following at least partial oxidation of the fuel (12). Fuel (14) and heat (28) can be supplied to the reforming zone (26) in a method for reacting fuel (12) and oxidant (16, 18, 20) into reformat.

5 REFORMER AND METHOD FOR CONVERTING FUEL
 ~~Reformer and method for converting fuel and oxidant into~~
 ~~reformat~~AND OXIDANT INTO REFORMATE

Background of the Invention

10 Field of the Invention

10 100011 The invention relates to a reformer for converting
 fuel and oxidant into reformat, comprising an oxidation
 zone and a reforming zone, wherein a mixture of fuel and
 oxidant may be supplied to the oxidation zone, and the
15 mixture may be supplied at least partially to the reforming
 zone upon an at least partial oxidation of the fuel.

Description of Related Art

20 100021 The invention relates further to a method for
 converting fuel and oxidant into reformat in a reformer
 having an oxidation zone and a reforming zone, wherein a
 mixture of fuel and oxidant is supplied to the oxidation
 zone, the mixture being supplied at least partially to the
 reforming zone upon an at least partial oxidation of the
25 fuel.

100031 Generic reformers and generic methods provide numerous
 fields of application. In particular, they serve for
 supplying a fuel cell with a hydrogen-rich gas mixture,
 from which electric energy may be generated on the basis of
30 electrochemical processes. Such fuel cells are employed,
 for example, in the automotive field as auxiliary power
 sources, so called APUs ("auxiliary power unit").

35 100041 The reforming process for converting fuel and oxidant
 into reformat may proceed according to various concepts.
 For example, the catalytic reforming is known, in which
 part of the fuel is oxidized in an exothermic reaction.
 This catalytic reforming has the drawback of a high heat
 generation which may irreversibly harm the system
40 components, in particular the catalytic converter.

100051 Another possibility for generating reformat from
 hydrocarbons is the "steam-reforming". In this process,
 hydrocarbons are converted within an endothermic reaction
45 into hydrogen by the aid of water vapor.

5 10006 A combination of these both concepts, that is, the
reforming on the basis of an exothermic reaction and the
production of hydrogen by means of an endothermic reaction
in which the energy for steam-reforming is extracted from
the combustion of hydrocarbons, is called an autothermic
reforming. Herein, the additional drawbacks arise that a
possibility for supplying water has to be provided. High
temperature gradients between the oxidation zone and the
reforming zone constitute further problems in the
10 temperature management of the entire system.

15 10007 An example ~~for~~ of a reformer having an oxidation unit
which is separated from a reforming unit is given in German
Patent Application DE 199 43 248 A1, which corresponds to U.S. Patent No.
6,613,466. Additionally, in U.S. Patent Application Publication 20050198899, a system
a disclosed that has a reaction chamber which is suited for at least partially oxidizing the
anode exhaust gas before it is supplied to the reformer. The at least partial oxidation of
the anode exhaust gas increases the amount of water which is delivered into the
20 reformer, by which the reforming efficiency is distinctly improved. Furthermore, the
reformer has a reaction space to which fuel, the at least partially oxidized anode exhaust
gas and the residual air remaining after at least partial oxidation can be supplied. In this
way, the oxidized anode exhaust gas and the remaining residual air can, if necessary, be
preheated by oxidation prior to being introduced into the reaction space of the reformer;
this has a very advantageous effect on reforming in many cases.

Summary of the Invention

25 10008 The invention is based on the object to provide a
reformer and a method for converting fuel and oxidant into
reformat, in which the mentioned problems are overcome at
30 least partially and in which, in particular, problems due
to high temperatures and large temperature gradients do not
occur, respectively.

35 10009 This object is solved in accordance with the features of
invention by fuel and heat being additionally supplied to the independent
claims - reforming zone.

Advantageous embodiments of the invention are defined in
the dependent claims.

40 10010 The invention is established beyond the generic
reformer in that fuel may additionally be supplied to the
reforming zone, and in that heat may be supplied to the
reforming zone. The additionally supplied fuel thus forms

5 together with the exhaust gas from the oxidation zone, the starting gas mixture for the reforming process. Due to the mixing of the fuel with the exhaust gas, a small λ -value is provided (for example $\lambda = 0.4$), and an endothermic reforming reaction can take place by supplying heat.

10 ~~100111~~ In this context, it is especially beneficial that heat from the exothermic oxidation within the oxidation zone may be supplied to the reforming zone. The heat energy resulting from the oxidation zone is thus converted in the course of the reforming reaction such that the net heat generation of the entire process does not lead to problems in the temperature management of the reformer.

15 ~~Advantageously~~ ~~100121~~ Advantageously, it is provided that the reforming zone comprises an oxidation supply through which oxidant may be additionally supplied. In this manner, a further parameter for influencing the reforming is provided, in order to optimize it.

20 ~~100131~~ The invention is, in a very beneficial manner, further developed in that the additional fuel may be supplied to an injection and mixture forming zone and in that the additional fuel can flow from the injection and mixture forming zone into the reforming zone. This injection and mixture forming zone is thus arranged upstream of the reforming zone such that the reforming zone is provided with a well mixed starting gas for the reforming reaction.

30 ~~100141~~ In this context, it is especially beneficial that the additional fuel is at least partially evaporated by the thermal energy of the gas mixture exiting the oxidation zone. Thus, the reaction heat from the oxidation may be utilized in a beneficial manner also for the evaporation process of the fuel.

40 ~~100151~~ Further, it may be beneficial that the gas mixture generated in the oxidation zone may be partially supplied to the reforming zone, bypassing the injection and mixture forming zone. Thereby, a further possibility for influencing the reforming process is provided such that a further improvement of the reformat exiting the reformer can be achieved with regards to its usage.

5 100161 The invention is established beyond the generic method in that additional fuel is supplied to the reforming zone, and in that heat is supplied to the reforming zone. In this manner, the advantages and special characteristics of the reformer according to the present invention are achieved also in the course of a method. This also applies for the following especially preferred embodiments of the method according to the present invention.

10 100171 This method is beneficially further developed in that heat from the exothermic oxidation within the oxidation zone is supplied to the reforming zone.

15 100181 Further, it may be beneficial that the reforming zone comprises an oxidant supply through which additional oxidant is supplied.

20 100191 Within the scope of the method, it is preferred that the additional fuel is supplied to an injection and mixture forming zone and that the additional fuel flows from the injection and mixture forming zone into the reforming zone.

25 100201 In relation to the method, it is beneficially envisaged that the additional fuel is evaporated at least partially by the thermal energy of the gas mixture exiting the oxidation zone.

30 100211 Further, it can be provided that the gas mixture which is produced in the oxidation zone is partially supplied to the reforming zone, bypassing the injection and mixture forming zone.

35 100221 The invention is based on the conclusion that, by separating the oxidation zone and the reforming zone, and by mixing the exhaust gas from the oxidation zone with the additionally supplied fuel, a gas mixture may be produced which provides good preconditions with regards to the following reforming and/or which can be optimized by the further supply of exhaust gas and oxidant with regards to
40 the reforming process.

45 100231 The invention is now explained by way of example referring to the accompanying drawings and the preferred embodiments.

~~The drawings show in:~~ Brief Description of the Drawings

100241 Figure 1—isa schematic diagram of a reformer according to the present invention; and ~~in~~

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100251 Figure 2—isa flow chart for explaining a method according to the present invention.

Detailed Description of the Invention

10 100261 Figure 1 shows a ~~schematic diagram of a reformer 10~~ according to the present invention. ~~Fuel to which fuel 12 and~~
oxidant 16 can be supplied ~~to the reformer 10 through from~~
respective supplies. For the fuel 12, for example, diesel
15 ~~fuel~~ may be considered, and the oxidant 16 is usually air.
The reaction heat generated instantaneous within the
initial combustion may be partially discharged in an
optionally provided cooling zone 36. The mixture then
further proceeds into the oxidation zone 24 which can be
20 realized as a pipe which is arranged within the reforming
zone 26. In alternative embodiments, the oxidation zone is
realized by multiple pipes or a specific pipe arrangement
within the reforming zone 26. Within the oxidation zone, a
conversion of fuel and oxidant within an exothermic
reaction having $\lambda \approx 1$ takes place. The gas mixture 32
25 produced thereby then enters an injection and mixture
forming zone 30 in which it is mixed with injected fuel 14.
The thermal energy of the gas mixture 32 can thereby
support the evaporation of the fuel 14. Additionally, it
can be provided that oxidant is supplied into the injection
30 and mixture forming zone 30. The thus formed mixture then
enters the reforming zone 26 where it is converted in an
endothermic reaction, with, for example, $\lambda \approx 0.4$. The heat 28
needed for the endothermic reaction is discharged from the
oxidation zone 24. For optimizing the reforming process,
35 oxidant 18 may be additionally supplied into the reforming
zone 26. Further, it is possible to directly supply part of
the gas mixture 34 which is produced in the oxidation zone
24 to the reforming zone 26, bypassing the injection and
mixture forming zone 30. The reformat 22 then flows out of
40 the reforming zone 26 and is available for further
utilization.

100271 Figure 2 shows a flow chart for explaining a method
45 according to the present invention. In step S01, fuel and
oxidant is supplied to an oxidation zone. Thereafter, in
step S02, an at least partial oxidation of the fuel occurs.

According to step S03, the gas mixture exiting the oxidation zone is supplied to the injection and ~~gas mixture~~ forming zone. Further, in step S04, additional fuel is supplied to the injection and ~~gas mixture~~ forming zone. The mixture produced in the injection and mixture forming zone is then supplied in step S05 to the reforming zone, where it is reformed in step S06 within an endothermic reaction, utilizing the reaction heat of the exothermic oxidation. In step S07, the reformat is extracted.

100281 The features of the present invention disclosed in the preceding description, ~~in and~~ the drawings ~~and in the claims~~ can be ~~essential~~ utilized for the implementation of the invention, individually and in combination.

~~Reference numerals:~~

~~12 — fuel~~

~~14 — fuel~~

~~16 — oxidant~~

~~18 — oxidant~~

~~20 — oxidant~~

~~22 — reformat~~

~~24 — oxidation zone~~

~~26 — reforming zone~~

~~28 — heat~~

~~30 — injection and mixture forming zone~~

~~34 — gas mixture~~

~~36 — cooling zone~~